WHITE LIGHT SOURCE (marked-up version)

This application is a continuation-in-part of application 10/464,111, filed June 19, 2003, now pending.

BACKGROUND OF THE INVENTION

(1) *Field of the Invention*: This invention relates to light source, particularly to the use of multi-color light emitting diode (LED) light source to produce a white light.

(2) *Brief Description of Related Art*: Fig.1A shows a prior art to produce a colorless white light. The light source uses three color LEDs to produce a white light. A red color LED R , a green color LED G, and a blue color LED B are mounted on a substrate 10, The three LEDs are then covered with a glue for protection.

Fig.1B shows the color spectrum of such a light source. The red LED has a light spectrum with wavelength in the 580 nm-680 nm range and a peak at 640 nm. The green LED has a light spectrum with wavelength in the 480 nm-580 nm range and a peak at 530 nm. The blue LED has a light spectrum with wavelength in the 430 nm- 530 nm range and a peak at 480 nm. The white light in nature has light spectrum ranging from 400-780 nm wavelength. The artificial white light source using the R, G, B LEDs has peaks at 640 nm, 530 nm and 480 nm wavelengths, but lacks light spectrum below 430 nm wavelength , around 500 nm wavelength, around 580 nm wavelength and above 680 nm wavelength. Therefore, the combination of three color LEDs does not reproduce a true colorless light.

SUMMAR OF THE INVENTION

An object of this invention is to produce a colorless light source having the same light spectrum as the white light in nature. Another object of this invention is to produce a white light source with broader light spectrum than using the three color R, G, B LEDs. Still another object of this invention is to lower the cost of reproducing colorless light than the cost of using three color R, G, B LEDs.

These objects are achieved by using only two color LEDs and coving them with color phosphorescent glue. Alternatively, a single color LED is covered with two kinds of colored phosphorescent glues.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1A shows a prior art light source using three color LEDs.

Fig. 1B shows the light spectrum of the 3-color LED light source.

Fig. 2A shows a first embodiment of the present invention, using a green LED, a blue LED and a red phosphorescent glue.

Fig. 2B shows the light spectrum of the light source shown in Fig. 2A.

Fig. 3A shows a second embodiment of the present invention, using a red LED, a blue LED and a green phosphorescent glue.

Fig. 3B shows the light spectrum of the light source shown in Fig.3A.

Fig. 4A shows a third embodiment of the present invention, using a blue LED, and a red phosphorescent glue; Fig.4B shows the light spectrum of the light source shown in Fig.4A.

Fig. 5A shows a fourth embodiment of the present invention, using a blue LED, a green LED, a yellow phosphorescent glue and a red phosphorescent glue; Fig.5B shows the light spectrum of the light source shown in Fig.5A.

DETAILED DESCRIPTION OF THE INVENTION

In recent years, the "red phosphorescent glue" (SrS:Eu) and the "green phosphorescent glue" ($SrGa_2S_4$:Eu) become popular. The cost is lower than the LED chips and the light spectrum is broader than a LED. These properties are utilized to produce a colorless light in the present invention.

Fig. 2A shows the first embodiment of the present invention. A green color LED G and a blue color LED B are mounted on an insulating substrate 10, such as a printed circuit board, to which the color LEDs can be coupled by wire-bonding or flip-chip technique. These two LEDs G and B are covered with a red phosphorescent glue R1. The light emitted from this structure is colorless as shown in the color spectrum in Fig.2B. Note the red color spectrum of the red phosphorescent glue complements the colors of the LEDs and is considerably broader than the red LED spectrum response shown in Fig. 1A. Hence, the overall spectral response is also broader, approaching that of true natural white light.

Fig. 3A shows the second embodiment of the present invention. A red color LED R and a blue color LED B are mounted on a substrate 10. These two LEDs R and B are covered with a green phosphorescent glue G1. The light emitted from this structure is colorless as shown in the color spectrum in Fig. 3B. Note that the spectral response due to the green phosphorescent glue G1 complements the colors of the LEDs, and is broader then the green LED response shown in Fig. 1B.

As a result, the spectral response is more uniform than that in Fig. 1B, approaching that of true natural white light.

Fig. 3A shows the third embodiment of the present invention. A single blue color LED B is mounted on a substrate 10. The LED B is cover with a green phosphorescent glue G1 and a red phosphorescent glue R1. The light emitted from this structure approaches that of a natural white light as shown in the spectral response in Fig.4B. Note that responses due to the G1 phosphorescent glue and the R1 phosphorescent glue complement the color of the blue LED and are considerably broader than the corresponding green LED and red LED responses. Thus, the overall response shown in Fig.4B is more uniform than that in Fig.1B, approaching that of true natural light. Alternatively, a mixture of the green and red phosphorescent glue may also be used.

Fig.5A shows a fourth embodiment of the present invention. A blue LED B and a green LED G are mounted on the same substrate 10. The substrate together with the mounted blue LED and the green LED is covered with a yellow phosphorescent glue Y1 and a red phosphorescent glue R1. The blue light excites the yellow phosphorescent glue to emit yellow light and the red phosphorescent glue to emit red light. The combination of these colors results in a while light. The light emitted from this structure approaches that of a natural white light as shown in the spectral response in Fig.5B. The yellow phosphorescent glue Y1 can enhance the response in 534nm-608 nm range. In comparison with Fig. 2A, 2B, this embodiment approaches more the white light spectrum. In this embodiment, Y1 phosphorescent glue may be deposited above or below the red phosphorescent glue, and may also be mixed with the red phosphorescent glue.

While the preferred embodiments of the invention have been described, it will be apparent to those skilled in the art that various modifications may be made to the embodiments without departing from the spirit of the present invention. Such modifications are all within the scope of this invention.